THE OPEN UNIVERSITY OF SRI LANKA
B. Sc. Degree Programme — Level 4
Assignment II (Test)— 2006/2007
(Part I/ 1-7- Thermodynamics)
CHU 2124/CHE 4124 — Physical Chemistry I

$\left(1\frac{1}{2}\text{ hours}\right)$

25th August 2006 3.30 p.m. — 5.00 p.m.

Gas constant (R)	=	$8.314\ \text{J K}^{-1}\text{mol}^{-1}$
Avogadro constant (N_A)	=	$6.023\times10^{23}\ \text{mol}^{-1}$
Faraday constant (F)	=	$96,500\ \text{C mol}^{-1}$
Planck constant (h)	=	$6.63\times10^{-34}\ \text{J s}$
Velocity of light (c)	=	$3.0\times10^{8}\ \text{m s}^{-1}$
Standard atmospheric pressure	=	$10^{5}\ \text{Pa}\left(\text{N m}^{-2}\right)$
$\text{Log}_e(X)$	=	$2.303\ \text{Log}_{10}(X)$

- Please write your **Registration number, Name, and Address** clearly in the space provided; see **last page** of this question paper.

⊠ The paper has **two** parts, A and B.
⊠ There are 20 (twelve) Multiple Choice Questions in **PART – A** and 02 (two) Structured Questions in **PART – B.**
⊠ Use a **PEN** (not a PENCIL) in answering.
⊠ The use of a *non-programmable* electronic calculator is permitted.
⊠ Logarithm tables will be provided if desired.

PART – A, Multiple Choice Questions.

⊠ In answering, choose the most correct answer to each of the questions and mark this answer with an "X" on the answer script for PART – A, in the appropriate box.
⊠ Any answer with more than **one** "X" marked will be considered as an *incorrect* answer.
⊠ Each correct answer will score 05 marks.
⊠ Marks will be deducted for incorrect answers ($\frac{5}{6}$ per answer).

PART – B, Structured Questions.

⊠ Write down your answers in the spaces provided in PART – B of this question paper itself.

PART – A (70 %)

1. Identify one set of properties which comprise entirely of **extensive thermodynamic properties.**

   (a) U, H, P (b) $G, H, C_{P,m}$ (c) P, T, V_m

   (d) S, U, V (e) C_P, G, P

2. Identify one set of properties which comprise entirely of **intensive thermodynamic properties.**

   (a) U, H, P (b) $G, H, C_{P,m}$ (c) P, T, V_m

   (d) S, U, V (e) C_P, G, P

3. For a spontaneous process which one of the following expressions will NOT apply.

   (a) $dS_{system} > \frac{Dq}{T}$ (b) $dS_{isolated} > 0$ (c) $dA_{V,T} < 0$

   (d) $dG_{P,T} < 0$ (e) $dU = Dq + Dw$

4. 100 mol of a monatomic ideal gas $\left(C_{V,m} = \frac{3R}{2}\right)$ at 300 K is subjected to a reversible and adiabatic expansion until the final temperature was 100 K. The change in internal energy is

   (a) 30,000 R (b) 50,000 R (c) – 50,000 R

   (d) – 300 R (e) – 30,000 R.

5. The entropy change (**in J K^{-1}**) that occurs when 5 mol of an ideal gas ($C_{p,m}$ = 30.0 J K^{-1} mol^{-1}) is heated from 27^0C to 2727^0C at standard atmospheric pressure is approximately equal to

   (a) 150 (b) 80.5 (c) 345

   (d) -150 (e) -345

6. The equation $\Delta H = n C_{P,m} \Delta T$ will apply for

   (a) any homogeneous system at constant pressure.
   (b) ideal gas at constant pressure.
   (c) ideal gas under all conditions.
   (d) any gaseous system at constant pressure.
   (e) all systems indicated in answers (a) to (d) above.

   given that $C_{P,m}$ is the isobaric molar thermal capacity of the system.

Questions 7 and 8 refer to the data given below.

Consider the condensation of 10 moles of water vapour to liquid water at its standard boiling point of 373 K under standard atmospheric pressure. Assume that water vapour behaves as an ideal gas and that the molar volume of liquid water is negligible relative to the volume of its vapour. Enthalpy of vaporisation of water at its standard boiling point is $41\ kJ\ mol^{-1}$.

7. The work done on the gas during the condensation, **in units of kJ,** is approximately, equal to

(a) – 62 (b) – 31 (c) + 31
(d) + 62 (e) – 93

8. What is the change in Gibbs free energy, in units of kJ, accompanying the condensation?

(a) – 400 (b) + 390 (c) + 500
(d) + 250 (e) zero.

9. If the vapour pressure of a liquid is increased ten times for a raise of temperature from 300 to 400 K, the mean molar enthalpy of evaporation, in units of $\mathrm{kJ\ mol^{-1}}$, of this liquid (assumed to remain constant) using the Clausius–Clapeyron equation is

(a) 2.71 R (b) 2.76 R (c) 2.81 R
(d) 2.86 R (e) 2.91 R

10. Given the following standard entropies, calculate the standard entropy of formation of ammonia, in units of $\mathrm{J\ K^{-1}\ mol^{-1}}$.

Substance	$N_2(g)$	$H_2(g)$	$NH_3(g)$
$S^0/\mathrm{J\ K^{-1}\ mol^{-1}}$	101.5	130.5	192.5

(a) – 108 (b) – 39.5 (c) – 54
(d) – 216 (e) – 79

11. $0.005\,\mathrm{mol}$ of each of the following substances were dissolved in 100 g of water. The lowering of the freezing point of water is a maximum for

(a) barium chloride (b) acetic acid (c) sodium chloride
(d) sugar (e) nitric acid

12. Given the following standard Gibbs free energies, in units of $\mathrm{kJ\ mol^{-1}}$, at $25^0\mathrm{C}$ and one atmosphere pressure, what is the standard molar Gibbs free energy of combustion of liquid benzene in units of $\mathrm{kJ\ mol^{-1}}$. [G^0 for $C_6H_6(\ell) = 150$; $CO_2(g) = -400$; $H_2O(\ell) = -250$]

(a) – 4,050 (b) – 3,300 (c) – 3,200
(d) – 3,100 (e) 3,300

13. The SI unit of entropy (S) is

(a) $\mathrm{J\ K^{-1}}$ (b) J K (c) $\mathrm{J\ mol\ K^{-1}}$ (d) $\mathrm{J\ mol^{-1}\ K^{-1}}$ (e) $\mathrm{J^{-1}\ K^{-1}}$

14. In an adiabatic process (in which the work done on the system is W), the heat change (q) and the change in internal energy are respectively equal to

(a) zero and zero (b) W and zero (c) zero and W
(d) zero and – W (e) -W and zero

15. The Maxwell Type relationship that you could derive from the equation (similar to a thermodynamic equation of state) $\mathbf{dE = M\,dJ - K\,dL}$ (where the symbols used are all extensive thermodynamic properties) is

(a) $\left(\frac{\partial M}{\partial L}\right)_J = \left(\frac{\partial K}{\partial J}\right)_L$ (b) $\left(\frac{\partial M}{\partial L}\right)_J = -\left(\frac{\partial K}{\partial J}\right)_L$ (c) $\left(\frac{\partial M}{\partial J}\right)_L = \left(\frac{\partial K}{\partial L}\right)_J$

(d) $\left(\frac{\partial M}{\partial J}\right)_L = -\left(\frac{\partial K}{\partial L}\right)_J$ (e) $\left(\frac{\partial E}{\partial L}\right)_J = \left(\frac{\partial M}{\partial J}\right)_L$

16. Which of the following descriptions will most correctly describe the process of freezing of liquid water to solid ice at its freezing point?

(a) Reversible, isothermal process

(b) Reversible, isochoric process

(c) Univarient Phase transformation

(d) Irreversible, Isochoric process

(e)Isobaric, isothermal Process

17. A Joule Thompson expression can be best described by which of the following?

(a) An isoenthalpic process

(b) A liquefaction process

(c) A cooling process

(d) An adiabatic process

(e) An isochoric process

18. The equation $\Delta S = nC_{v,m}\ln\left(\frac{T_2}{T_1}\right) + nR\ln\left(\frac{V_2}{V_1}\right)$ will apply for a change of state from state

A(V_1, T_1) to B(V_2, T_2) only for

(1) an ideal gas at constant pressure

(2) an ideal gas at constant volume

(3) for any homogeneous system under all conditions.

(4) for an ideal gas under all conditions but for any other homogeneous system only at constant volume

(5) an ideal gas under all conditions.

19. 10 moles of Oxygen ($C_{v,m} = \frac{5R}{2}$) at 100 bar and 300 K undergo reversible adiabatic change to a final temperature of 200 K. The internal energy change, ΔU, for the above transformation is equal to

(a) 2500 R (b) -2500 R (c) 1500 R (d) -1500 R (e) zero

20. The thermodynamic equilibrium constant, K, for a reaction at 227 °C is 10. The Gibbs free energy change for this reaction at this temperature (**in J mol^{-1}**) is about

(a) 2490 (b) -2490 (c) - 4336 (d) 5730 (e) - 5730

THE OPEN UNIVERSITY OF SRI LANKA
B.Sc DEGREE PROGRAMME 2006/2007
CHU 2124/CHE 4124 - PHYSICAL CHEMISTRY - LEVEL 4
ASSIGNMENT TEST - MCQ TEST 2

MCQ ANSWER SHEET: Mark a cross (x) over the most suitable answer.

Reg.No.

FOR EXAMINERS ONLY	
Correct Answers	
Wrong Answers	
Marks	

1.	a	b	c	X d	e	2.	a	b	X c	d	e	3.	a	b	c	d	X e
4.	a	b	c	d	X e	5.	a	b	X c	d	e	6.	a	b	X c	d	e
7.	a	b	X c	d	e	8.	a	b	c	d	X e	9.	a	X b	c	d	e
10.	a	b	X c	d	e	11.	X a	b	c	d	e	12.	a	X b	c	d	e
13.	X a	b	c	d	e	14.	a	b	X c	d	e	15.	a	X b	c	d	e
16.	a	b	X c	d	e	17.	X a	b	c	d	e	18.	a	b	c	X d	e
19.	a	X b	c	d	e	20.	~~a~~	~~b~~	~~c~~	~~d~~	~~e~~	all					

0

PART – B (30%)

1. (a) $\frac{\partial\left(\frac{\Delta G}{T}\right)}{\partial T} = -\frac{\Delta H}{T^2}$ at constant pressure is one form of the Gibbs-Helmholtz equation.

Derive the corresponding integrated form of this equation in the temperature range T_1 to T_2

(25 marks)

(b) Consider the following half equation:

$$\frac{1}{2}Cl_2(g) + e \rightarrow Cl^-(aq) \qquad E^\circ = +1.36\ V \text{ at } 298\ K$$

Also, the variation of ΔH with temperature (T) is given as $\Delta H = (50000 - 50\ T)\ J\ mol^{-1}$

(i) Calculate ΔG° at 298 K using the relationship between ΔG° and standard electrode potential with respect to the above electrode reaction

(10marks)

(ii) Hence, calculate ΔG° at 350 K

(25 marks)

2. (a) Define (i) "Colligative Property"
(ii) molality

(15 marks)

(b) An unknown, non volatile compound, X, is suspected to be Biphenyl and, it was decided to confirm this by carrying out an experiment in the physical chemistry laboratory to determine its molar mass

A solution was prepared by dissolving 0.300 g of this compound in 30.0 g of carbon tetrachloride. The observed boiling point of this solution was 0.325 K more than that of the pure solvent.

With the aid of an appropriate calculation, answer the following :

"Is the compound ,X, Biphenyl or not?"

(Molar ebulioscopic constant, K_{1000} for CCl_4 = 5.00 K kg mol^{-1})

(Relative Atomic Mass: H = 1.0; C = 12.0; O = 16.0)

(25 marks)

Answer Guide to Assignment Test II PART – B (30%)

(Pages referred to corresponds to the study material - Themodynamics-Part I)

1. (a) Refer Page 67 -68

(b) (i) Refer Page 73

(ii) Refer Page 68 - Answer : ΔG° at 350 K = -160 kJ mol^{-1}

2. (a) (i) Refer Page 86

(ii) molality – number of moles of solute per kilogram of solvent

(b) **Refer Page 93, question 5** and the corresponding answer in **Page 150** which corresponds to Napthalene of molar mass 128 g

The answer in this case gives a value of **154 g** which corresponds to the molar mass of Biphenyl ($C_{12}H_{10}$)

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